

## Caustic Soda

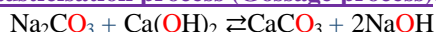
### Sodium Hydroxide (Caustic Soda), NaOH:

- ❖ Sodium hydroxide, NaOH, is a soft, waxy, white, corrosive solid.
- ❖ It is commonly known as lye or caustic soda.
- ❖ It is one of the important chemicals and is manufactured on a very large scale forming an important chemical industry.
- ❖ It is most conveniently manufactured by one of the following processes:
  1. Methods involving sodium carbonate as a starting material.
  2. Methods involving sodium chloride as starting material.

### Methods involving sodium carbonate as a starting material:

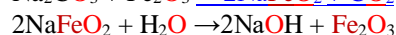
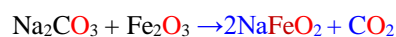
- ❖ Two methods are used. These are

#### (i) Causticisation process (Gossage process):



- ❖ The temperature is maintained 80-90°C by blowing steam. Caustic soda solution is drained out and evaporated to dryness when flakes of caustic soda are obtained.
- ❖ The most suitable concentration of sodium carbonate taken in this process is 15-20%.
- ❖ The caustic soda produced by this method is not pure and contains some calcium carbonate, sodium carbonate and calcium hydroxide as impurities.

#### (ii) Lowig's process:

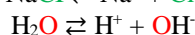
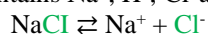


- ❖ The solution is filtered and evaporated to dryness to get flakes of sodium hydroxide.

### Methods involving sodium chloride as starting material:

Methods used are electrolytic as the electrolysis of sodium chloride solution is carried out in an electrolytic cell.

**Principle:** A sodium chloride solution contains  $\text{Na}^+$ ,  $\text{H}^+$ ,  $\text{Cl}^-$  and  $\text{OH}^-$  ions.



- ❖ On passing electricity,  $\text{Na}^+$  and  $\text{H}^+$  ions move towards cathode and  $\text{Cl}^-$  and  $\text{OH}^-$  ions move towards anode. The discharge potential of  $\text{H}^+$  ions is less than  $\text{Na}^+$  ions, thus hydrogen ions get discharged easily and hydrogen is liberated. Similarly, at anode  $\text{Cl}^-$  ions are easily discharged as their discharge potential is less than that of  $\text{OH}^-$  ions.  $\text{Cl}_2$  gas is therefore, liberated at anode.
- ❖ The solution on electrolysis becomes richer in  $\text{Na}^+$  and  $\text{OH}^-$  ions.
- ❖ Since, chlorine reacts with sodium hydroxide solution even in the cold forming sodium chloride and sodium hypochlorite, it is necessary that chlorine should not come in contact with sodium hydroxide during electrolysis:



- ❖ To overcome this problem, the, anode is separated from the cathode in the electrolytic cell either by using a porous diaphragm or by using a mercury cathode. Four methods are used, these are:

(i) Porous diaphragm process (Nelson cell process)

(ii) Castner-Kellner cell

(iii) Solvay-Kellner cell

(iv) Diaphragm cell

### Properties:

#### Physical Properties:

- ❖ It is a white crystalline solid. It has soapy touch.
- ❖ It is highly deliquescent.
- ❖ Its density is 2.13 g/mL and melting point 318.4°C.
- ❖ It is highly soluble in water. It is bitter in taste.
- ❖ It is corrosive in nature.
- ❖ Its solubility is comparatively less in alcohol.

#### Uses:

- ❖ Sodium hydroxide is among the top ten industrial chemicals. It is an important industrial chemical because it is an inexpensive base for the production of other sodium salts. It is a strong base, and this property is useful in many applications. It is used:
  - ✚ As a reagent in the laboratory.
  - ✚ In refining of petroleum.
  - ✚ In the manufacture of soap.
  - ✚ In the manufacture of sodium metal.
  - ✚ In the manufacture of paper and rayon.
  - ✚ In the manufacture of dyes and drugs.
  - ✚ As an absorber of gases.
  - ✚ In the manufacture of sodium hypochlorite, sodium chlorate and sodium nitrite.
  - ✚ For mercerizing cotton.
  - ✚ In large quantities in the production of aluminium which depends on its reaction with the amphoteric aluminium hydroxide.

### Sodium Thiosulphate(Hypo) $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$

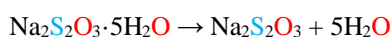
- ❖ It is the sodium salt of an unstable acid, thiosulphuric acid ( $\text{H}_2\text{S}_2\text{O}_3$ ). It is also known as hypo. The following methods can be used for its preparation:
  - It is obtained by boiling sodium sulphite solution with flowers of sulphur.
 
$$\text{Na}_2\text{SO}_3 + \text{S} \rightarrow \text{Na}_2\text{S}_2\text{O}_3$$
  - Spring's reaction:** The mixture of sodium sulphite and sodium sulphide is treated with calculated quantity of iodine.
 
$$\text{Na}_2\text{S} + \text{I}_2 + \text{Na}_2\text{SO}_3 \rightarrow \text{Na}_2\text{S}_2\text{O}_3 + 2\text{NaI}$$
  - When the solution containing sodium carbonate and sodium sulphide is treated with sulphur dioxide, sodium thiosulphate is formed with evolution of carbon dioxide.
 
$$2\text{Na}_2\text{S} + \text{Na}_2\text{CO}_3 + 4\text{SO}_2 \rightarrow 3\text{Na}_2\text{S}_2\text{O}_3 + \text{CO}_2$$

$$4\text{S} + 6\text{NaOH} \rightarrow \text{Na}_2\text{S}_2\text{O}_3 + 2\text{Na}_2\text{S} + 3\text{H}_2\text{O}$$
 With excess of sulphur, sodium pentasulphide is formed
 
$$\text{Na}_2\text{S} + 4\text{S} \rightarrow \text{Na}_2\text{S}_5$$
  - $$\text{Na}_2\text{CO}_3 + \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 + \text{CO}_2$$

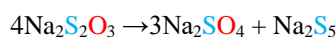
$$\text{Na}_2\text{SO}_3 + \text{S} \rightarrow \text{Na}_2\text{S}_2\text{O}_3$$

#### ❖ Properties:

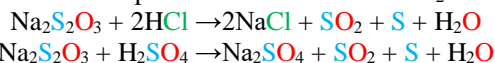
- ❖ It is a colourless crystalline solid consisting of 5 molecules of water as water of crystallisation.
- ❖ It has the formula,  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ .
- ❖ It is soluble in water.
- ❖ It melts at  $48^\circ\text{C}$ .
- ❖ **Action of heat:** It is efflorescent substance. The water molecules are completely lost when heated at  $215^\circ\text{C}$ .



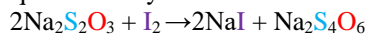
- ❖ When strongly heated above  $223^\circ\text{C}$ , it decomposes forming sodium sulphate (salt cake) and sodium pentasulphide.



- ❖ **Reaction with acids:** Dilute acids decompose it with evolution of  $\text{SO}_2$  and precipitation of sulphur.

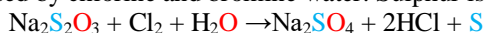


- ❖ **Oxidation:** It is oxidised by iodine quantitatively.



Sodium tetrathionate

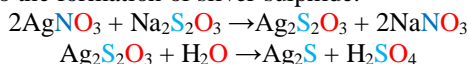
- ❖ **Reducing action:** It is oxidised by chlorine and bromine water. Sulphur is precipitated.



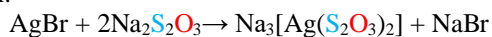
It reduces  $\text{FeCl}_3$  to  $\text{FeCl}_2$



- ❖ **Reaction with  $\text{AgNO}_3$ :** A white precipitate of silver thiosulphate is obtained which changes to yellow, brown and finally black due to the formation of silver sulphide.

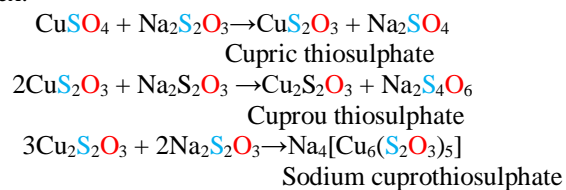


- ❖ Reaction with silver halides: Halides form complexes with sodium thiosulphate. Silver bromide forms argentothiosulphate complex.



Sodium argentothiosulphate

- ❖ Similar reactions are observed with AgCl and AgI.
- ❖ This property is utilised in photography for fixing the negative and positive of black and white photography. It removes undecomposed AgBr present on the film.
- ❖ **Reaction with copper sulphate:** Cuprous thiosulphate is formed which dissolves in excess of sodium thiosulphate to form a complex.



- ❖ **Uses:**
- ❖ As an antichlor to remove excess of chlorine from bleached fabrics.
- ❖ In the extraction of silver and gold.
- ❖ In photography as a fixing agent in the name of hypo.
- ❖ As a reagent in iodometric and iodimetric titrations for the estimation of iodine,  $\text{CuSO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ ,  $\text{KMnO}_4$ ,  $\text{Na}_3\text{AsO}_3$  etc.

#### References:

- ❖ Industrial Inorganic Chemistry by Karl Heinz Buchel Hans-Heinrich Moretto Peter Woditsch, Second Edition WILEY-VCH.
- ❖ A Textbook of Inorganic Chemistry by O. P. Tandon
- ❖ Principles of Inorganic Chemistry by Puri, Sharma and Kalia